Salinity Study in the Casamance Estuary: Modeling and Observations

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Abstract

The estuary of the Casamance River, in southern Senegal,experiences significant salinity variations, reaching up to 50 psu in the dry season and 20 psu in the wet season, with an inversion of the landward salinity gradient during the dry period. Studying salinity fluctuations is necessary to better understand its hydrodynamics, particularly in the context of regional climate change. To study the estuary, fine scale (200 m) 3D numerical simulations using the CROCO model were analyzed. The sensitivity of the model sea level height, circulation and salinity was explored through numerous simulations with varying forcing, including wind variability, tidal forcing, the presence (during the wet season) or absence (during the dry season) of river discharge.

First, the model's friction was calibrated using simulated and observed tidal sea level. While the tidal sea levels showed good agreement, the simulated tidal currents were underestimated by 50%. The Lagrangian residual circulation was estimated from the drift of Lagragian particles: it was primarily directed upstream, and much slower than the Eulerian residual circulation, which was directed downstream.

Salinity fluctuations were studied based on the analysis of numerical simulations and longitudinal transects conducted near the estuary mouth. Observations revealed strong longitudinal gradients, weak vertical stratification, and high seasonal variability. Model results showed that the abrupt salinity decrease during the rainy season is influenced by both the river discharge (provided by GLOFAS) and the brackish water salinity imposed upstream. Despite realistic hydrodynamics, the salinity increase during the dry season was underestimated. Analysis of the vertically integrated salinity budget revealed that the salinity increase in the dry season was mainly driven by evaporation and advection, counterbalanced by horizontal mixing.

This work is first step in the hydrodynamic modeling of the Casamance estuary. Improvements, such as extending the modeled domain upstream and incorporating more reliable hydrological models to provide runoff, are necessary to improve our representation of this complex system.